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Abstract

The Use of Power Reactors as Large-Scale Radiation-Sources for Radiation-Chemical Production

by

F. Herre, W. Herzog, S. Rösinger, W. Schütze and A. Wacker,
Farbwerke Hoechst AG

In the core of power reactors, a high-intensity radiation is produced, most of which must be annihilated in the thermal and biological shield. Various possibilities of chemical utilization of this radiation have been shown. Such utilization may take place either in the "chemistry reactor", so called[1] (irradiation in the core) or in the "blanket reactor"[1] (irradiation in the reflector range). The use of nuclear reactors as large-scale radiation sources for radiation-chemical reactions requires a reactor giving a high γ-dose rate in a large volume (in order to achieve a satisfactory chemical production rate) and a neutron flux not exceeding a certain limit (to keep contamination by activation far below the MPC). These two requirements cannot yet be met within the scope of the suggestions made so far and with the reactors known at present. For this purpose, reactors of entirely novel design would have to be developed, which seems impossible in the near future.

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[1] Summary: KRAUCH, H.: Dechema Monographien, Vol. 42, p. 145 (1962).

We are suggesting in this paper the "compound reactor" as a new conception. It is characterized by the fact that the chemical reaction takes place outside the reactor vessel; in this case, the chemical plant takes over, in whole or in part, the function of the thermal shield. Such "compound reactor" permits economical chemical production since it utilizes only the "waste"-radiation of the reactor which has otherwise to be annihilated in the radiation shield.

Any technically perfected power reactor may be used, without the necessity of interfering in the neutron economy. The utilization of fuel, therefore, is not reduced. A reactor of this type should have low γ-self-absorption of the core, of the reflector and, if necessary, of the thermal shield, and should be operated at a low moderator pressure. Boiling water reactors and pressurized water reactors are not suitable as "compound reactor" types because they require too large amounts of material for the pressure vessel; reactors according to the GCR principle are also not suitable because of their poor power density and large amounts of moderator. A suitable reactor type, however, would seem to be, for instance, a pressure-tube reactor with small amounts of moderator and gas cooling at medium pressures, since in this case the γ-absorption in the core and in the container material can be made as small as possible, and the neutron absorption as high as possible.

The proposed "compound reactor" has the following advantages:

1) Energy generation and radiation-chemical production are practically independent of each other and take place under optimum conditions.
2) Reactor safety is not impaired.
3) The irradiation space for radiation chemistry is not restricted.
4) The neutron flux can be shielded to a given limiting value without interfering in the neutron economy.
5) Free selection of the reaction parameters (pressure, temperature) and the material of the reaction vessels for the radiation-chemical reaction.

6) Facilitated maintenance of the chemical plant.

For some technically interesting reactions which take place in the liquid phase, the amounts that can be produced are calculated for several pressure-tube reactors (CVTR, AKB). E.g., using the radiation data given in the literature, the following production amounts can be estimated for the AKB reactor (300 MW_{th}) in a reaction volume of approximately 30 m^3: hexadecane sulphonic acid 4,000 tons per month; ethyl bromide 70,000 tons per month.

The compound reactor as a combination of energy generation and chemical production may well contribute to economic utilization of nuclear energy.